

radiation rather than by molecular heat transfer. Thus, gravito-photophoretic lofting forces are most effective within the altitude range between 10 and 85 km, making aircraft soot emitted in commercial flight corridors subject to lofting up to the mesosphere.

The current mass loading of soot in the middle atmosphere is too small to cause a direct absorption effect that would be comparable to the extinction of light by scattering on mesospheric cloud particles. However, it is conceivable that soot in the mesosphere has indirect effects by providing freezing nuclei for mesospheric ice particles to form. In addition, soot might contribute to the ionization of the mesosphere to affect the appearance of polar mesospheric summer radar echoes.

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## Physical and Chemical Properties of Aerosols and Cloud Particles

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Recent modeling studies have suggested a link between black carbon aerosol (BCA) and ozone chemistry via the reduction of nitric acid, nitrogen dioxide, and ozone on BCA particles. The ozone reaction converts ozone to oxygen molecules, while nitric acid can react to form nitrogen oxide ( $\text{NO}_x$ ). Also, a buildup of BCA could reduce the single-scatter albedo of aerosol below a value of 0.98, a critical value that has been postulated to change the radiative effect of stratospheric aerosol from cooling to warming. Correlations between measured BCA amounts and aircraft usage have been reported.

Attempts to link BCA to ozone chemistry and other stratospheric processes have been hindered by questions concerning the amount of BCA that exists in the stratosphere, the magnitude of reaction probabilities, and the scarcity of BCA measurements. The primary objectives of the Ames team (as part of the Photochemistry of Ozone Loss in the Arctic Region in Summer (POLARIS) mission) were (1) to determine the distribution of sulfate and soot aerosols, and (2) to determine the role of these aerosols in stratospheric photochemistry.

To facilitate measurements, a system that automates the operation of the Ames Wire Impactors (AWI) was designed, fabricated, and flown successfully on POLARIS. This system alleviates the pilot workload and allows the experimenter the flexibility to sample at predetermined altitudes, locations, or temperatures.

Because of the fractal nature of BCA, modification of the AWI data-analysis procedures was required in which the collection of BCA is modeled as a fractal aggregate. The new method results in an increase in the measured BCA surface area of about 15 times and an increase in soot loading of about 6 times over the previously used approach. Despite this increase, BCA surface area is only about 10% of the measured sulfuric acid aerosol surface area.

Including heterogeneous reactions on BCA in a photochemical model can affect photochemistry, leading to renoxification and increased ozone depletion. However, these predicted effects are not supported by the POLARIS observations, in particular the nitrogen oxide/reactive nitrogen ( $\text{NO}_x/\text{NO}_y$ ) ratios. Including BCA reactions does not statistically improve the agreement between model and measurement in any of several scenarios considered. Furthermore, if the reactions cause even partial carbon oxidation, the BCA would be consumed at a rate inconsistent with POLARIS observations. These inconsistencies lead to the conclusion that the presence of BCA in the stratosphere did not affect stratospheric photochemistry during POLARIS.

Measurements of aircraft plumes indicate that aircraft emit substantial numbers of volatile and nonvolatile particles during flight. These observations have caused concern that commercial aviation sources may significantly influence heterogeneous processes, cloud formation, and microphysics in the

upper troposphere and lower stratosphere. As part of the Subsonic Assessment (SASS) Ozone and Nitrogen Oxides Experiment (SONEX), the objectives of the Ames team were (1) to measure the distribution of aerosol and cloud during the mission in order to determine the fraction of total aerosol that can be attributed to aircraft-generated sulfur, and (2) to determine the relevance of this aerosol as a marker of aircraft-influenced air and its effects on the regional climate.

An instrument based on the thermal volatilization of aerosols was fabricated and flown on the SONEX mission to discriminate sulfuric acid, ammonium sulfate/bisulfate, and nonvolatile aerosols during the mission. Using this instrument, a significant increase in the sulfuric acid aerosol was observed under conditions where other indicators suggested that the air parcels were influenced by aircraft exhaust. Most of these occurrences were above 9 kilometer (km) altitude. The sulfuric acid aerosols do not appear to measurably affect surface area and volume of the background aerosol because of their small diameter, and, therefore, do not appear to affect radiative transfer directly. Only a very small fraction of the nonvolatile aerosols could be identified as BCA.

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## Quantifying Denitrification and Its Effect on Ozone Recovery

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Upper Atmospheric Research Satellite (UARS) observations indicate that denitrification occurs in the Antarctic, without significant dehydration, during mid to late June (see figure 1). In contrast, UARS data show no indication for the presence of large-scale denitrification in the Arctic, even during the coldest winters of the last decade (see figure 1). The fact that denitrification occurs in the Antarctic in a relatively warm month raises concern about the possibility for the occurrence of this event in a future colder, and possibly more humid, lower stratosphere, as a result of climate change and/or natural variability, and its subsequent effect on ozone recovery. Polar stratospheric cloud (PSC) lifetimes required for Arctic denitrification to occur in the future were contrasted against the current Antarctic cloud lifetimes during early and mid to late June. Ozone sensitivity calculations show that widespread denitrification can enhance future Arctic ozone loss by about 40% during the coldest winters of the next century.

It is well known that PSCs play an important role in the formation of the springtime Antarctic "ozone hole" by activating chlorine and denitrifying the stratosphere. Because similar levels of active chlorine concentrations have been measured in both polar vortices, the lack of extensive denitrification observed in the Arctic has been speculated to be one of the main factors currently preventing the formation of an Arctic "ozone hole." At Ames, and for the first time, a quantitative study was done on the denitrification process that explains why this event currently occurs extensively in the Antarctic and not the Arctic, using data obtained from numerous different instruments onboard the UARS.

Until now, a few studies have implied that Arctic denitrification, during the coldest winters of the last decade, has already contributed significantly to the depletion of ozone inside the Arctic vortex. On the other hand, a wealth of available information suggests that the apparent and simultaneous loss of both ozone and reactive nitrogen in the Arctic is often purely a result of dynamical mixing of different air masses with high and low values of both species that is unrelated to denitrification. Also, most in situ and